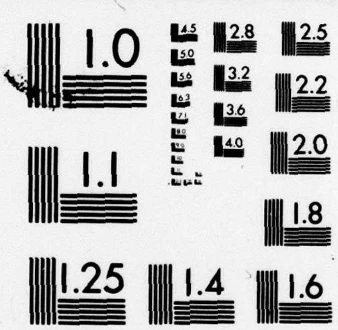
AD-A071 941 STANFORD UNIV CALIF EDWARD L GINZTON LAB F/G 17/1
SIGNIFICANT ACCOMPLISHMENTS UNDER THE JOINT SERVICES ELECTRONIC--ETC(U)
SEP 76 N00014-75-C-0632
UNCLASSIFIED GL-2617 NL

1 OF 1
AD
A071941

END
DATE
FILMED
8-79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

427
373 361

2

Edward L. Ginzton Laboratory
W. W. Hansen Laboratories of Physics
Stanford University
Stanford, California

SC

LEVEL II

6

"SIGNIFICANT ACCOMPLISHMENTS"

Under the

JOINT SERVICES ELECTRONICS PROGRAM

Contract N00014-75-C-0632

15

9 Rept. for 1 Jun 75-31 May 76

For the Period

June 1, 1975 - May 31, 1976

14 GL-

G. L. Report No. 2617

11 Sep 1976

12 6p.

409640

1P

SUMMARY

SIGNIFICANT ACCOMPLISHMENTS

Contract N00014-75-C-0632

1. New Acoustic Imaging Techniques

The basic aim of this work was to design high quality acoustic wave transducer arrays with as many as 100 elements suitable for acoustic imaging. This requires: (1) a very uniform response from element to element, (2) small coupling between the elements, (3) broad bandwidth, (4) a design procedure which would yield predictable characteristics, (5) ideally high efficiency of conversion of acoustic power to electrical power, and vice versa. We have satisfied criteria 1 - 4, and are well on the way to satisfying 5.

When we started this work, only single element commercial transducers were available. Although this is a well worked over subject, we found that the response of such transducers were not uniform over their cross-section, or from one sample to the other, and their conversion loss was of the order of 25 - 40 dB. This implied that good uniform high efficiency multiple element arrays would be still more difficult to construct. Furthermore, as the element cross-section became comparable to the wavelength, it was not possible to predict the frequency response or impedance of the transducer, or the effective acoustic impedance of the backing on which it was mounted. Furthermore, more sophisticated design procedures needed to be developed to match to water with $\lambda/4$ matching layers, and predict the optimum broadband matching to this partially resonant system. The development of sophisticated theories of this kind had been out of the question before this time, because of the poor state of the bonding technology.

We use a tungsten powder filled epoxy backing material with an impedance close to that of the ceramic transducer. We have taken great trouble to vacuum sputter clean the ceramic transducer, and have then applied the tungsten powder to the transducer under pressure in a 20 ton press. Then we vacuum impregnate the epoxy and cure it under pressure in the vacuum system. This makes a reliable reproducible bond. With this technique, we have been able to make transducers which are uniform from element to element, and whose characteristics are in excellent agreement with theory.

The theory has been developed, and is still in the process of development, to predict the effective impedance of a backing material to an element of finite extent whose cross-section is much less than a wavelength. This involves the use of a variational theory which determines the magnitude of the longitudinal waves, shear waves, and Rayleigh waves excited in the backing medium by the transducer element. We then calculate the power delivered into these waves. Effective backing impedance turns out to be very close to that of an infinite transducer when the element size is large enough. As the width of the transducer becomes smaller, there are, of course,

reactive components introduced. More importantly, still, the development of this theory leads us to a logical way for determining the coupling between transducer elements due to the presence of the backing. We are presently extrapolating the theory for this purpose and comparing it with measurements on cross-coupling that we have carried out during the year. The measured cross-coupling can be as low as 29 dB between neighboring elements, and can be seen, experimentally, to be associated with acoustic propagation, in the backing, of a relatively nondispersive wave.

We have also determined that when a face plate is put on the front of the transducer array, it can give cross-coupling due to shear waves in the medium, rather than longitudinal waves. Thus, it becomes imperative to use a fairly soft material for the face plate which cannot propagate shear waves. We have used mylar tape for this purpose.

We have developed multiple layer $\lambda/4$ matching elements for large cross-section transducers, using two layers, glass and epoxy, for this purpose. This work was carried out on another program and leads to a new way of designing high efficiency octave bandwidth transducers. We have begun to test these principles on slotted arrays. So far, the results look encouraging; encouraging enough that we expect to obtain similar results on transducer arrays before the end of the present project.

2. Study of Acoustic Wave Propagation in Poly Vinylidene Fluoride

It was shown in Japan that poly(vinylidene)fluoride (PVF_2) plastic films can be made strongly piezoelectric by simple processing procedures. We have been working with films of this kind during the past two years, and have demonstrated the first practical ultrasonic transducers using this material, which appear to circumvent some of the outstanding problems and limitations of existing transducers for nondestructive testing and nondestructive evaluation (NDE) of materials, and other applications. We first made measurements of the electroacoustic properties of the material, by means of acoustic resonance experiments in unsupported film samples, finding very favorable values of piezoelectric coupling constant, acoustic Q and acoustic impedance. Using this information we constructed transducer structures of a type suitable for radiating acoustic beams into water, as is commonly done in NDE work. In these transducers the PVF_2 film is bonded to a solid backing rod, and is acoustically loaded by both the backing rod and the water. These transducers are superior to commercial PZT ceramic transducers in terms of bandwidth, impulse response and upper frequency, as well as in certain mechanical respects and cost potential.

In NDE, acoustic beams generated by single transducers or by arrays of transducers are sent into materials or structures to be tested, and scattered echoes from faults or other inhomogeneities are measured. Large bandwidth is important in these systems. It allows narrow pulses to be used to obtain high range resolution in time domain spectrometry. It allows different center frequencies to be used to optimize the response from

different faults. It allows frequency swept signals or other signals of large bandwidth to be used for pulse compression or for electronic focusing to increase resolving power and dynamic range. Extremely large bandwidth capability has been demonstrated with our PVF_2 transducers, including a flat frequency response from zero to 20 MHz. Very clean impulse response is also observed with these transducers, consisting of a single bipolar pulse, free of the spurious ringing characteristic of standard PZT transducers which obscures echoes from faults located close to the transducer.

We feel that PVF_2 transducers have a very strong potential for application in the NDE field. Their availability in arbitrarily large sizes and their mechanical flexibility and strength may make it possible to carry out rapid nondestructive surveys of large area objects and objects with curved surfaces by placing the films directly against the surface of the object. We find that PVF_2 films have a very low acoustic impedance, which not only makes possible the bandwidth and impulse response characteristics discussed above, but also allows efficient coupling into water and we expect it to also facilitate efficient coupling directly into test objects, using intermediate transforming layers fabricated from flexible film materials. We find that conducting electrodes are readily deposited on the surfaces of PVF_2 films, and feel that these films may become an important alternative to PZT for the construction of large transducer arrays for electronic scanning and focusing of acoustic beams. We find that PVF_2 films have clean resonances at 40 MHz and prospects of going to higher frequencies, and may thus be applicable to NDE work requiring higher frequencies than available with PZT, in order to achieve higher resolution, such as in the study of flaws in ceramic structures.

3. Studies of the Electrical Behavior of Superconducting Quantum Devices Using High-T_c Materials

Two years ago we initiated a program in superconducting electronics with the general objective of trying to learn how to incorporate high transition temperature (T_c) superconductors into practical superconducting devices. We are continuing to have success and have fabricated Nb_3Sn ($T_c = 18^oK$) films and oxide layer tunnel junctions of sufficient quality to be of real device interest. This success has been made possible by our continuing mastery over the materials problems associated with the fabrication of thin films of high-T_c superconductors. Materials problems abound in any energing technology and our success represents a significant step forward. The films were produced using electron-beam co-deposition. As is well known high-T_c superconductors have generally superior properties (e.g., superconducting energy gaps as well as T_c) and hold the promise of being able to operate at higher temperatures than the materials commonly used now, say above ~ 12-14^oK where quite reliable, small, closed-cycle refrigerators are available commercially. This could be very important in small superconducting systems such as magnetometers, high-frequency receivers and precision voltage standards where only a few superconducting devices are required.

Specifically, we have fabricated for the first time Nb_3Sn oxide-layer tunnel junctions (incorporating a Pb counterelectrode) which exhibit I-V characteristics with both large energy gaps ($\Delta Nb_3SN + \Delta Pb = 4.9$ meV) and very low leakage conductance (2%) at low bias voltages. These two parameters are the important figures of merit gauging the quality of such devices. These junctions also exhibit well-developed Josephson tunneling, as reported last year. Oxide-layer Josephson junctions with such large energy gaps are of considerable device potential, say, in ac Josephson effect voltage standard applications when the poor coupling of radiation to such structures is not a serious disadvantage.

The excellent tunneling characteristics obtained with our Nb_3Sn films also demonstrates that the superconductivity of these films is not degraded at the surface, as has been so frequently a problem in previous work. This opens up for the first time the possibility of incorporating these films in super-Schottky diodes and high-temperature Nb_3Sn/Nb_3Sn Josephson junctions using semiconducting tunneling barriers. Both of these would be of really considerable technological importance but were thought to be completely beyond present-day materials capabilities. Our results hopefully have changed this situation.

4. Measurement of Fast Physical Processing Using Picosecond Laser Pulses

In previous research supported by JSEP, and earlier by NSF we have developed a novel "transient grating" laser technique. With this technique the time constants of very fast physical phenomena, occuring on a picosecond time scale, can be measured using mode-locked laser pulses. In brief, the physical phenomenon to be studied, such as a rapidly decaying excited molecular state, is excited in the form of a spatial grating pattern using two intersecting and interfering laser pulses. The decay of this excited-state grating is then probed stroboscopically by diffracting a third variable-delay probe pulse from the excited-state grating.

The specific physical process we are presently studying by means of this technique is the diffusion of exciton states in organic molecular crystals. Understanding the diffusion processes of such excitons is of great importance for understanding not only energy transfer processes in organic molecular chemistry, but also for understanding exciton diffusion in semiconductors and also in biological systems. In certain organic crystals which contain long unidirectional chains of organic molecules, the excitrons are believed to diffuse very rapidly along the direction of the molecular chains, but to diffuse only slowly perpendicular to the molecular chains. Such anisotropic diffusion of excitons has been proposed to explain many other phenomena, but has not yet been directly observed. Our grating technique has a unique capability for observing anisotropic exciton diffusion by creating the excitation grating pattern with the fringes either perpendicular of parallel to the rapid diffusion direction. In the first case the grating should decay very rapidly due to rapid diffusion of the excitons between fringes, while in the second case the fringe decay should be substantially slower.

At the present time we are attempting to demonstrate this effect in crystals of tetrachlorobenzene, which is a particular example of a crystal with a one-dimensional lattice structure. The exciton grating in this crystal is to be created by two-photon absorption from a 532 nm doubled-YAG exciting laser beam. At the minute we have succeeded in demonstrating the two-photon absorption, and in measuring a two-photon fluorescence spectrum, in a closely related organic crystal, napthalene. We hope to demonstrate the desired transient grating effect in the near future in this crystal (which has certain experimental advantages) and then proceed to one-dimensional crystals such as tetrachlorobenzene or dibromonapthalene.